(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 273 687 A2

# (12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
**08.01.2003 Bulletin 2003/02**

(51) Int Cl.[7]: **D03J 1/13**, D02H 9/00

(21) Application number: **02251911.0**

(22) Date of filing: **18.03.2002**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR**
Designated Extension States:
**AL LT LV MK RO SI**

(30) Priority: **30.05.2001 JP 2001163046**

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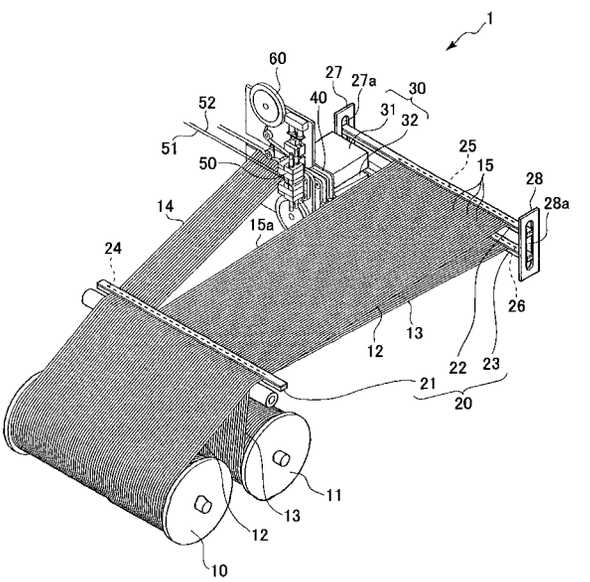
## (54) Warp rearrangement method and device

(57) A warp rearrangement device includes a multi-layer thread tension mechanism (20) that holds a plurality of warp sheets (12,13), from different warp beams (10,11), together at a warp-beam side holding position (21) and separate (25,26) at the thread tip side of the warp sheets so that the sheets are supported in a radial configuration centered on the warp-beam side holding position (21). A thread separation mechanism (30) separates warp threads (14) one at a time from optionally selected ones of the warp sheets (12,13). A thread end transport mechanism (40) catches the thread end of each separated warp thread and a thread-end holding portion (40a) transports the caught warp threads to a leasing mechanism (50) that leases the warp threads. Transportation is three-dimensional, centered on the warp-beam-side holding position (21), without changing thread length between the warp-beam-side holding position (21) and the thread-end holding portion (40a). A thread end fixing mechanism (60) fixes the thread end of leased warp threads.

FIG.1

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## Description

**[0001]** The present invention relates to a warp rearrangement method and device as a weaving preparatory operation performed before weaving a fabric using a weaving machine.

**[0002]** "Warp rearrangement" is an operation performed to arrange warps from two or more different warp sheets into a single warp sheet with a desired order. The warps of the different warp sheets can have different thicknesses, colors, or be made from different materials, such as natural fibers and synthetic fibers. "Warp rearrangement" is referred to as *garakumi* in Japanese.

**[0003]** Conventional warp rearrangement is performed by referring to a predetermined order table while manually aligning warps of different material, color, thickness, and the like in a desired order in a single-layer sheet shape. The warps rearranged in this manner are then passed one at a time through the dropper, the heddles, and the reed, before being dressed onto the loom.

**[0004]** However, this conventional process depends on manual operations and relies on the operator's vision. This places a large burden on the operator. Also, the conventional process takes even an experienced operator a long time to perform. The process is therefore not very efficient and results inevitably in mistakes.

**[0005]** It is an objective of the present invention to overcome the above-described problems and provide a warp rearranging method and device that enables automatic rearranging of warps from a plurality of different warp sheets.

**[0006]** According to the method of the present invention, first a plurality of warp beams are each wound with a different warp sheet. The warp sheets are formed from a plurality of warps aligned in a single-layer sheet shape. Next, the warp sheets are drawn from the plurality of warp beams and held together in a multi-layer condition at a warp-beam side holding position and separately at a thread tip side of each of the warp sheets. This supports the warp sheets separated and under tension in a radial configuration centered on the warp-beam side holding position. Then warps are separated one at a time from optionally selected ones of the held warp sheets, caught at a thread end thereof, and transported to a leasing position. The transport is performed three-dimensionally centered on the warp-beam-side holding position, without changing thread length between the warp-beam-side holding position and the caught thread end. Then the transported warps are leased at the leasing position and the thread ends of the leased warps are fixed together.

**[0007]** A warp rearrangement device according to the present invention includes a plurality of warp beams, a multi-layer thread tension mechanism, a thread separation mechanism, a thread end transport mechanism, a leasing mechanism, and a thread end fixing mechanism.

**[0008]** Each of the warp beams is wound with a different warp sheet formed from a plurality of warps aligned in a single-layer sheet shape.

**[0009]** The multi-layer thread tension mechanism includes an intermediate holding portion and a plurality of tip holding portions. The intermediate holding portion holds the warp sheets from the different warp beams together in a multi-layer condition at a warp-beam side holding position. The tip holding portions each hold a thread tip side of a different one of the holding sheets. Together, the intermediate holding portion and the tip holding portions support the holding sheets separated and under tension in a radial configuration that is centered on the warp-beam side holding position of the intermediate holding portion.

**[0010]** The thread separation mechanism separates the warps one at a time from the supported warp sheets. The warps are separated in a predetermined order from the warp sheets, depending on the desired rearrangement.

**[0011]** The thread end transport mechanism includes a thread-end holding portion that catches a thread end of each separated warp. The thread-end holding portion transports the caught warp three-dimensionally, centered on the warp-beam-side holding position, without changing thread length between the warp-beam-side holding position and the thread-end holding portion.

**[0012]** The leasing mechanism leases the transported warps and the thread end fixing mechanism fixes the thread end of leased warps.

**[0013]** With this method and device, the warps drawn out from the warp beams can be reliably rearranged and maintained in a predetermined order into a single-layer sheet. Subsequent preparations for weaving, such as passing the warps one at a time through the dropper, the heddles, and the reed, can be performed smoothly. For example, warp rearrangement can be automatically performed, wherein the warps of the warp beams can be automatically rearranged in a predetermined order and fixed in place so that the warps from one of the warp beams are aligned with warps from the other warp beam or beams. This reduces the labor burden on the operator and greatly enhances warp rearrangement operations.

**[0014]** The above and other objects, features and advantages of the invention will become more apparent from reading the following description of the embodiment taken in connection with the accompanying drawings in which:

Fig. 1 is perspective view showing a warp rearrangement device according to an embodiment of the present invention;

Fig. 2 is a side view showing the warp rearrangement device of Fig. 1;

Fig. 3 is a perspective view showing thread separation mechanisms and a thread-end transport mechanism of the warp rearrangement device of Fig. 1 at the beginning of a normal thread separation operation;

Fig. 4 is perspective view showing a thread separated from a warp sheet by the one of the thread separation mechanisms and transported to a thread cutting portion and to a thread-end catching position;

Fig. 5 is a perspective view showing a thread-end catching portion of a thread-end transport mechanism moving to the thread-end catching position of the thread in Fig. 4;

Fig. 6 is a perspective view showing the thread-end catching portion of Fig. 5 catching the thread;

Fig. 7 is a perspective view showing one of the thread cutting portions cutting the thread;

Fig. 8 is a perspective view showing the thread-end transport mechanism three-dimensionally transporting the cut thread upward and rearward;

Fig. 9 is a perspective view showing a leasing mechanism and a thread-end fixing mechanism processing the cut and transported thread into a warp sheet;

Fig. 10 is a perspective view showing the thread separation mechanisms, the thread cutting portions, and the thread-end transport mechanism at the beginning of an independent movement operation;

Fig. 11 is a perspective view showing one of the thread separation mechanisms and the corresponding cutter portion of Fig. 10 moving forward toward the warp sheet;

Fig. 12 is a perspective view showing the thread separation mechanism separating a thread from a warp sheet and transporting it rearward to the cutter portion;

Fig. 13 is a perspective view showing the cutter portion cutting'and holding the end of the thread;

Fig. 14 is a perspective view showing the cutter portion moving the thread rearward to the thread-end catching position;

Fig. 15 is a perspective view showing the thread-end catching portion moving to the thread held at the thread-end catching position by the cutter portion;

Fig. 16 is a perspective view showing the thread-end catching portion grasping the thread;

Fig. 17 is a perspective view showing the cutter portion releasing the thread;

Fig. 18 is a perspective view showing the thread-end transport mechanism transporting the thread in a three-dimensional manner; and

Fig. 19 is a perspective view showing the warp sheet produced by leasing and fixing operations after the separation/transport operations shown in Figs. 3 to 8 and 10 to 18.

**[0015]** Next, a warp rearrangement device 1 according to an embodiment of the present invention will be described while referring to Figs. 1 to 19. As shown in Fig. 1, the warp rearrangement device 1 includes a multi-layer thread tension mechanism 20, a thread separation mechanism 30, a thread-end transport mechanism 40, a leasing mechanism 50, and a thread-end fixing mechanism 60. The warp rearrangement device also includes a follower movement mechanism 70 as shown in Fig. 2 and thread-separator movement mechanisms 81, 82 and cutter portions 91, 94 as shown in Fig. 4.

**[0016]** The warp rearrangement device 1 is mounted with two warp beams 10, 11 wound with warp sheets 12, 13, respectively. The warp sheets 12, 13 are formed by aligning a plurality of warps 15 into a single-layer sheet shape. Depending on requirements of the final fabric, the warps 15 of the different warp sheets 12, 13 can be of the same or different materials, and have the same or different color or thickness. The resultant warp sheets 12, 13 are then wound onto the warp beams 10, 11, respectively.

**[0017]** As shown in Figs. 1 and 2, the multi-layer thread tension mechanism 20 includes an intermediate holding portion 21 and upper and lower tip holding portions 22, 23. The intermediate holding portion 21 holds both of the two warp sheets 12, 13 drawn from the two warp beams 10, 11 at the same holding position 24. The two tip holding portions 22, 23 separately hold the warp sheets 12, 13 at tip holding positions 25, 26 to support and apply tension to the warp sheets 12, 13.

**[0018]** The multi-layer thread tension mechanism 20 also includes tip holder guides 27, 28 formed with arc shaped slots 27a, 28a, respectively. The tip holding portions 22, 23 are slidably mounted in the slots 27a, 28a. As shown in Fig. 2, the slot 28a is formed with an arc shape that follows an imaginary arc 16a of an imaginary circle with a diameter 16b centered on the holding position 24 of the intermediate holding portion 21. The slot 27a is also shaped to follow the imaginary arc 16a. Although not shown the drawings, an adjustment mechanism is provided for fixing position of the tip holding portions 22, 23 at optional positions in the slots 27a, 28a. With this configuration, the tip holding portions 22, 23 can be separated vertically to support the warp sheets 12, 13 to radiate from the holding position 24 of the intermediate holding portion 21.

**[0019]** The thread separation mechanism 30 is for separating an edge thread 15a from a selected one of the upper and lower sheets 12, 13 and moving the edge thread 15a to the thread-end transport mechanism 40. As shown in Fig. 1, the thread separation mechanism 30 includes two thread separation blocks 31, 32. As shown in Fig. 3, the thread separation block 31 includes leasing strings 31a, 31b for leasing the warps 15 of the warp sheet 12 and the thread separation block 32 includes leasing strings 32a, 32b for leasing the warps 15 of the warp sheet 13. Although not shown in the drawings, the thread separation blocks 31, 32 also include well-known thread separation configuration for separating an edge warp 15a one at a time from the warp sheets 12, 13 in cooperation with the leasing strings 31a, 31b, 32a, and 32b and pulling a portion TP of the separated

thread from, as shown in Fig. 4, alignment with the sheet edges 12a, 13a to thread-end catching positions 40a, 40b of the thread-end transport mechanism 40 (to be described later). Although not shown in the drawings, a computer is provided with a thread selection program for controlling selection of warp sheets 12, 13. The thread selection program selects one of the warp sheets 12, 13 and drives the corresponding thread separation block 31, 32 to separate an edge warp 15a from the selected warp sheet 12, 13. This process is repeated to selectively separate the warps one at a time in a desired order from the warp sheets 12, 13. Although in the present embodiment, the thread separation mechanism 31 uses the leasing strings 31a, 31b, 32a, 32b to separate warps 15 from the warp sheets 12, 13, any thread separation mechanism that separates one thread at a time from the warp sheets could be used, such as a thread separation mechanism that does not require the warps to be in a leased condition.

**[0020]** The follower mechanism 70 follows changes in the position of the sheet edges 12a, 13a caused by separating and transporting edge warp 15a from the warp sheets 12, 13. The follower mechanism 70 moves the thread separation blocks 31, 32, the thread-end transport mechanism 40, the leasing mechanism 50, and the thread-end fixing mechanism 60 accordingly. The follower mechanism 70 includes a movement frame 71, a rack 72 attached to the body of the warp rearrangement device, a pinion 73 attached to the movement frame 71, and a transport motor 74 for rotating the pinion 73. The plurality of thread separation blocks 31, 32, which correspond to the warp sheets 12, 13, respectively, and the thread-end transport mechanism 40 are attached to the movement frame 71. Although not shown in the drawings, a thread detection sensor for detecting the sheet edges 12a, 13a of the warp sheets 12, 13 is also attached to the movement frame 71. The transport motor 74 rotates the pinion 73 a predetermined amount in order to move the movement frame 71 to follow movement of the edges 12a, 13a in synchronization with detection of the edges 12a, 13a by the thread detection sensor.

**[0021]** As shown in Fig. 4, cutting portions 91, 94 are aligned with the thread separation blocks 31, 32 on the thread-separator movement mechanisms 81, 82, respectively. Although not shown in the drawings, the thread-separator movement mechanisms 81, 82 each include a control motor for driving the upper and lower thread separation blocks 31, 32 to move independently from each other forward and rearward in between sheet edges 12a, 13a of the sheets 12, 13 and a position that corresponds to thread-end catching positions 40a, 40b of the thread-end transport mechanism 40 (to be described later). Because the cutting portions 91, 94 are aligned with the thread separation blocks 31, 32 on the thread-separator movement mechanisms 81, 82, the cutting portions 91, 94 move forward and rearward with the corresponding thread separation block 31, 32 as the thread separation blocks 31, 32 are moved toward and away from the sheets 12, 13 by the follower movement mechanism 70 and also as the thread separation blocks 31, 32 are moved independently by the thread-separator movement mechanisms 81, 82. Each cutting portion 91 includes a cutter 93 and a cutting member 92. The cutting member 92 operates in cooperation with the cutter 93 to cut warps interposed therebetween.

**[0022]** The computer (not shown) controls the cutting portions 91, 94 to operate differently when thread separation is performed in the normal fashion and when the thread separation blocks 31, 32 are moved independently from each other toward and away from the warp sheets 12, 13. That is, during a normal separation operation, after one of the thread separation blocks (31 for example) separates an edge warp 15a from the corresponding warp sheet (12 in this example), then the follower movement mechanism 70 moves both of the thread separation blocks 31, 32, and consequentially both of the cutting portions 91, 94, to the edges 12a, 13a of the warp sheets 12, 13 without the other warp sheet (13 in this example) interfering with forward movement of the other thread separation block (32 in this example).

**[0023]** On the other hand, if many threads are removed from the same sheet in sequence, then the sheet edge of that sheet will be positioned much further forward than the edge of the other sheet. For example, if many threads are removed from the sheet 12 in sequence, then the sheet edge 12a will be positioned much further forward than the edge 13a of the other sheet 13. If the edge 13a of the sheet 13 interferes with forward movement of the thread separation block 32, the follower movement mechanism 70 cannot move the thread separation block 31, and consequently cannot move the cutting portion 91, to the sheet edge 12a, so no further threads can be separated from the sheet 12. It should be noted that the same problem occurs when many threads are separated from the sheet 13 in sequence. In such a situation, the thread-separator movement mechanisms 81, 82 operate independently to move only one of the thread separation blocks 31, 32 so that threads can still be separated from the sheets 12, 13. This will be referred to as an independent movement operation, hereinafter.

**[0024]** Next, an example of the normal thread separation operation will be explained with reference to Figs. 4 to 8. As shown in Fig. 4, first the upper thread warp separation block 31 separates a single edge warp 15a from the upper warp sheet 12 and the thread separation configuration (not shown) of the upper thread warp separation block 31 pulls the edge warp 15a toward the upper separation block 31. As a result, the portion TP of the thread 15a moves from alignment with the edge 12a of the sheet 12 as shown in Fig. 3 to the thread-end catching position 40a as shown in Fig. 4. At this time, the edge warp 15a is positioned at the opening between the cutting member 92 and the cutter 93 of the cutting portion 91. After a thread-end catching portion 46 of the

thread-end transport mechanism 40 catches hold of the thread portion TP of the thread at the thread-end catching position 40a as shown in Figs. 5 and 6, then as shown in Fig. 7 the cutter 93 of the cutter portion 91 moves downward toward the cutting member 92 to cut the end-side of the edge warp 15a, and is then driven to immediately rise upward again.

**[0025]** Next, an example independent movement operation, wherein when one of the thread separation mechanisms 31, 32 is driven to move forward and rearward independently from the other, will be explained while referring to Figs. 10 to 18. In this example, the thread separation mechanism 31 is moved separately from the other thread separation mechanism 32. First, the thread-separator movement mechanism 81 moves the upper thread separation block 31 and the upper cutting portion 91 forward from the position shown in Fig. 10 to a position as near to the sheet edge 12a as possible as shown in Fig. 11. Once the upper thread separation mechanism 31 is at this forward position, then the thread separation configuration (not shown) of the upper thread separation mechanism 31 pulls a single edge warp 15a from the upper warp sheet 12 to the location of the cutter 93 as shown in Fig. 12. Then, as shown in Fig. 13, the cutter 93 of the cutting portion 91 lowers to cut the separated thread 15a. The cutter 93 does not immediately rise upward, but remains in its lowered position to hold the tip of the cut edge warp 15a between the cutter 93 and the cutting member 92. Next, as shown in Fig. 14, the thread-separator movement mechanism 81 moves the upper thread separation mechanism 31 and the upper cutting portion 91 rearward to pull the warp held by the cutter 93 to the thread-end catching position 40a of the thread-end catching portion 46. After the thread-end catching portion 46 catches the edge warp 15a at the thread-end catching position 40a as shown in Figs. 15 and 16, then as shown in Fig. 17 the cutter 93 of the cutting portion 91 rises up to release the tip of the edge warp 15a.

**[0026]** The thread-end transport mechanism 40 is for grasping the thread position TP of a separated edge warp 15a, whether separated by the normal thread separation operation or the independent movement operation, at the thread-end catching position 40a and then transporting the single edge warp 15a three-dimensionally centered on the holding position 24 of the intermediate holding portion 21, without changing the distance between the holding position 24 and where the thread-end transport mechanism 40 holds the thread 15a. As shown in Fig. 5, the thread-end transport mechanism 40 includes endless rotating belts 41a, 41b, a thread-end catching unit 45, and a guide groove portion 47. The guide groove portion 47 is disposed between the two rotating belts 41a, 41b and includes two flange portions 47a, 47c that define therebetween a groove 47b with an arc shape as viewed in Fig. 2.

**[0027]** The thread-end catching unit 45 includes attachments 42a, 42b, two slide shafts 43a, 43b, an attachment body 44, a thread-end catching portion 46, and an operation mechanism (not shown). The attachments 42a, 42b are attached to the rotating belts 41a, 41b. The slide shafts 43a, 43b are supported between the attachments 42a, 42b. The attachment body 44 is mounted on the slide shafts 43a, 43b slidable in the horizontal direction. Although not shown in the drawings, the attachment body 44 includes a roller that fits in the groove 47b. With this configuration, when thread-end catching unit 45 is transported upward by rotation of the rotating belts 41a, 41b, the attachment body 44 slides horizontally on the slide shafts 43a, 43b in association with the arc-shape of the groove 47b. The attachment body 44 is adapted for attaching the thread-end catching portion 46 thereto. The thread-end catching portion 46 includes a fixed holding cylinder 46a and a holding body 46b. The holding member 46b is capable of protruding from and retracting back toward the holding cylinder 46a and so can hold the edge warp 15a between the end surface of the holding cylinder 46a by retracting back and then releasing the tip of the edge warp 15a by protruding outward. The operation mechanism includes a motor (not shown) and an air compression cylinder (not shown). The motor drives rotational movement of the rotating belts 41a, 41b. The air compression cylinder operates to protrude and retract the holding body 46b from and toward the holding cylinder 46a at the thread-end catching position 40a to hold and release the edge warp 15a. Although not shown in the drawings, a plurality of thread-end catching units are provided with the same configuration as the thread-end catching unit 45 and are attached to the rotating belts 41a, 41b separated by a predetermined spacing.

**[0028]** As shown in Figs. 7, 8, 17, and 18, while the thread-end catching portion 46 holds the thread position TP, the transport mechanism 40 transports the cut edge warp 15a first substantially perpendicular to, and then substantially parallel to, planes defined by the warp sheets 12, 13 supported by the thread tension mechanism 20. In other words, the transport mechanism 40 transports the thread in a three-dimensional movement. Because the roller of the attachment body 44 follows the arc shape of the groove 47b and can shift leftward and rightward on the slide shafts 43a, 43b, the transport mechanism 40 can transport the edge warp 15a three-dimensionally centered on the holding position 24 of the intermediate holding portion 21 without any change in the thread length between the holding position 24 and the thread position TP where the thread-end catching position 40a holds the thread.

**[0029]** As shown in Fig. 9, the leasing mechanism 50 includes two leasing string holding pegs 51a, 51b. Each holding peg 51a, 51b has a wing formed with a hole. A leasing string 52, 52 is tied to each of the wings through the corresponding hole. The leasing strings 52, 52 are supported with tension by the pegs 51a, 51b and aligned in a direction that is perpendicular to the tension direction of the warps 15 transported one at a time by the

thread-end transport mechanism 40. Vertical movement mechanism (not shown) moves the holding pegs 51a, 51b vertically, which is a direction perpendicular to the tension direction of the edge warp 15a, in alternation so that when the holding peg 51a is in an upper position, the other holding peg 51b is in a lowered position, and vice versa. As shown in Fig. 9, each time the thread-end catching portion 46 of the thread-end transport mechanism 40 brings a single edge warp 15a to the leasing mechanism 50, one of the pegs 51a, 51b moves up and the other moves down to perform a leasing operation, wherein the leasing strings 52, 52 hold the order of the warps 15 aligned in a single-layer sheet shape.

**[0030]** The thread-end fixing mechanism 60 sandwiches the ends of the warps 15, which are transported one after the other by the thread-end transport mechanism 40 as shown in Fig. 9, between two strips of adhesive tape 61, 62 to fix the ends of the warps 15 in place and form a single layer sheet as shown in Fig. 19.

**[0031]** With the above-described configuration, as shown in Figs. 1 and 2, the two warp beams 10, 11 are prepared, wound with the warp sheets 12, 13, respectively, which are formed from a plurality of warps 15 aligned in a single-layer sheet shape. The two warp sheets 12, 13 are drawn from the warp beams 10, 11 and passed between the intermediate holding portions 21 to the tip holding portions 22, 23 as two separate layers. The intermediate holding portion 21 holds the portion of the two warp sheets 12, 13 near the warp beams 10, 11 and the mutually separated tip holding portions 22, 23 support the two warp sheets 12, 13 to radiate in different directions applied with tension. The thread separation blocks 31, 32 separate the warps 15 one at a time from selected ones of the two warp sheets 12, 13 using the normal thread separation operation that was described with reference to Figs. 3 to 8 or the independent movement operation that was described with reference to Figs. 10 to 18. The thread-end catching portion 46 of the thread-end transport mechanism 40 catches the thread position TP of the separated single edge warp 15a at the thread-end catching position 40a. As shown in Figs. 8 and 18, the thread-end transport mechanism 40 transports the edge warp 15a three dimensionally without changing the thread length between the holding position 24 (which is near the warp beams 10, 11) and the thread position TP. As shown in Fig. 9, the leasing mechanism 50 performs a leasing operation on the warps 15 that were transported one at a time by the thread-end transport mechanism 40. The thread-end fixing mechanism 60 fixes the ends of the warps 15 that were transported one at a time so that the warps 15 can be fixedly aligned in a single-layer sheet 100 shown in Fig. 19. Accordingly, by repeatedly performing this process, the warps 15 drawn out from the warp beams 10, 11 can be reliably rearranged and maintained in a predetermined order into the single-layer sheet 100. Subsequent preparations for weaving, such as passing the warps one at a time through the dropper, the heddles, and the reed, can be performed smoothly. For example, warp rearrangement can be automatically performed, wherein the warps 15 of the warp beams 10, 11 can be automatically rearranged in a predetermined order and fixed in place so that the warps 15 from the warp beam 10 are aligned with warps 15 from the other warp beam 11. This reduces the labor burden on the operator and greatly enhances warp rearrangement operations.

**[0032]** In this case, in the normal thread separation operation described with reference to Figs. 3 to 8, one of the thread separation blocks 31, 32, for example, the thread separation block 31, selectively separates a single warp 15a from the corresponding warp sheet 12 and also pulls the single edge warp 15a, at the thread portion TP thereof between the holding position 24 (near warp beams 10) and the thread-tip side of the thread-end holding position 25, to the thread-end catching position 40a. After the thread-end catching portion 46 catches the edge warp 15a, the corresponding cutting portion 91 cuts the end of the edge warp 15a. Therefore, the separated edge warp 15a can be reliably transferred to the thread-end transport mechanism 40.

**[0033]** In the independent movement operation described with referenced to Figs. 10 to 18, one of the thread separation blocks 31, 32, for example the thread separation block 31, separates the single edge warp 15a selectively from the corresponding warp sheet 12 and pulls the edge warp 15a to the cutting portion 91. The cutter 93 is driven to move downward and remain there, thereby simultaneously cutting the edge warp 15a and grabbing the end of the edge warp 15a. Then the thread-separator movement mechanism 81 moves the thread separation block 31 and the cutting portion 91 rearward to pull the edge warp 15a to the thread-end catching position 40a. After the thread-end catching portion 46 catches the edge warp 15a at the thread-end catching position 40a, then the cutter portion 93 releases the end of the edge warp 15a. As a result, the edge warp 15a can be reliably transferred to the thread-end transport mechanism 40.

**[0034]** Because the positions of the two tip holding portions 22, 23 of the multi-layer thread tension mechanism 20 can be adjusted by moving the tip holding portions 22, 23 along an imaginary arc of an imaginary circle centered on the holding position 24 of the intermediate holding portion 21 and then fixing the tip holding portions 22, 23 in place, the warp sheets 12, 13 can be supported with tension in a radial arrangement without changing the thread length between the holding position 24 and the tip holding positions 25, 26 of the tip holding portions 22, 23. The position of the threads 15 relative to the thread separation blocks 31, 32 can be that much more easily adjusted. Also, because a separate thread separation mechanism 31, 32 is provided for each of the warp sheets 12, 13, the relative positions between the warp sheets 12, 13 and the thread separation blocks 31, 32 can be easily adjusted and the warps 15 can be smoothly separated from the warp sheets 12, 13. In this

case, the follower movement mechanism 70 moves the thread separation blocks 31, 32, the thread-end transport mechanism 40, the leasing mechanism 50, and the thread-end fixing mechanism 60 to follow changes that occur in position of the sheet edges 12a, 13a of the warp sheets 12, 13 as warps 15 are separated from the warp sheets 12, 13. Because the follower movement mechanism 70 is provided, the relative positions of the warp sheets 12, 13, the thread separation blocks 31, 32, the thread-end transport mechanism 40, the leasing mechanism 50, and the thread-end fixing mechanism 60 can be properly maintained with changes associated with warps 15 being separated from the warp sheets 12, 13. The configuration is much simpler than if the warp beams 10, 11 and the multi-layer thread tension mechanism 20 where moved to follow changes associated with the warps 15 being separated from the warp sheets 12, 13. The warp sheets 12, 13 that have been subjected to leasing process as described above, can be smoothly moved to subsequent processes for preparing to dress the loom so that operations are that much easier.

**[0035]** In this case, because the thread-separator movement mechanisms 81, 82 are provided to move the thread separation blocks 31, 32 reciprocally in an independent manner between the sheet edges 12a, 13a and the thread-end catching position 40a of the thread-end catching portion 46, the thread separation blocks 31, 32 can be moved reciprocally in an independent manner to the optimum thread separation position, which depends on the position of the sheet edges 12a, 13a of the warp sheets 12, 13. If the thread separation blocks 31, 32 were only moved together in an integral manner, then situations would arise when one of the separation blocks could no longer separate threads from the warp sheets. For example, when performing warp rearrangement for a pattern with broad stripes, a first thread separation mechanism separates many threads one after the other from the same warp sheet, while the other thread separation mechanism remains inactive. As a result, the sheet edge of the other warp sheet will be much closer to the thread separation mechanisms than the sheet edge of the first warp sheet. If the thread separation mechanisms are moved integrally, then the other sheet separation mechanism will abut against its warp sheet, thereby preventing the first thread separation mechanism from moving close enough to the warp sheet to separate any more threads. Also, there are situations when the positions of the sheet edges 12a, 13a can be easily placed out of alignment, for example, when the threads of the warp sheets 12, 13 are loosely arranged (not densely grouped together). In both of these situations, the thread-separator movement mechanisms 81, 82 can move the thread separation blocks 31, 32 forward and rearward independently from each other to the optimum position for thread separation in accordance with the sheet edges 12a, 13a of the warp sheets 12, 13. As a result, there is greater freedom in the patterns that can be subjected to the warp rearrangement processes. Also, flexibility with respect to variation in position of the sheet edges 12a, 13a can be increased. The labor required to hang the threads can be decreased and the ease of handling the threads can be enhanced.

**[0036]** In this case, because the thread-end fixing mechanism 60 uses a pair of confronting adhesive tapes 61, 62, the ends of the warps 15 can be fixed in an aligned fashion in a single-layer sheet 100. The configuration is simpler. Also, because the multi-layer thread tension mechanism 20 supports the warp sheets 12, 13 to apply tension to the warp sheets 12, 13 in a direction that falls substantionally within an imaginary plane defined by the warp sheet 100, which is produced by subjecting the warp sheets 12, 13 to warp rearrangement, it is easy for the operator to monitor operations of the warp rearrangement device.

**[0037]** While the invention has been described in detail with reference to specific embodiments thereof, it would be apparent to those skilled in the art that various changes and modifications may be made therein.

**[0038]** For example, the embodiment describes preparing two warp beams 10, 11 and suspending two warp sheets 12, 13. However, three or more warp beams could be prepared and the same number of warp sheets could be suspended. Warp rearrangement could be performed by selecting warps from these warp sheets. Also, configuration of the multi-layer thread tension mechanism 20, the thread separation blocks 31, 32, the thread-end transport mechanism 40, the leasing mechanism 50, the thread-end fixing mechanism 60, the follower movement mechanism 70, and the thread-separator movement mechanisms 81, 82 could be modified as appropriate.

## Claims

**1.** A warp rearranging method comprising:

preparing a plurality of warp beams, each wound with a warp sheet formed from a plurality of warps aligned in a single-layer sheet shape;
drawing the warp sheets from the plurality of warp beams;
holding a warp-beam side of the warp sheets together in a multi-layer condition at a warp-beam side holding position;
holding a thread tip side of each of the warp sheets to support the warp sheets separated and under tension in a radial configuration centered on the warp-beam side holding position;
separating warps one at a time from optionally selected ones of the held warp sheets;
catching a thread end of each separated warp;
transporting the caught warp three-dimensionally centered on the warp-beam-side holding position without changing thread length between the warp-beam-side holding position and

the caught thread end;
leasing the transported warps; and
fixing the thread end of the leased warps.

**2.** A warp rearrangement method as claimed in claim 1, wherein the step of separating warps includes pulling a warp portion located between a held warp-beam-side and a held thread tip of the warp, to a thread-end catching position where the thread end of the separated warp is to be caught, and further comprising cutting the thread end of the separated warp after the separated warp is caught at the thread-end catching position.

**3.** A warp rearrangement method as claimed in claim 1, further comprising:

simultaneously cutting and holding the separated warp at a portion of the warp located between a held warp-beam-side and a held thread tip of the warp;
pulling the held warp to a thread-end catching position;
catching the warp at the thread-end catching position; and
releasing the held portion of the warp.

**4.** A warp rearrangement device comprising:

a plurality of warp beams, each wound with a warp sheet formed from a plurality of warps aligned in a single-layer sheet shape;
a multi-layer thread tension mechanism including:

an intermediate holding portion that holds a warp-beam side of each warp sheet drawn from the plurality of warp beams, the intermediate holding portion holding the warp sheets together in a multi-layer condition at a warp-beam side holding position; and
a plurality of tip holding portions each holding a thread tip side of a corresponding one of the holding sheets to support the holding sheets separated and under tension in a radial configuration centered on the warp-beam side holding position of the intermediate holding portion;

a thread separation mechanism that separates warps one at a time from optionally selected ones of the warp sheets held by the tip holding portions;
a thread end transport mechanism including a thread-end holding portion that catches a thread end of each warp separated from the warp sheets by the thread separation mechanism, the thread-end holding portion transporting the caught warp three-dimensionally, centered on the warp-beam-side holding position, without changing thread length between the warp-beam-side holding position and the thread-end holding portion;
a leasing mechanism for leasing warps transported one at a time by the thread end transport mechanism; and
a thread end fixing mechanism that fixes the thread end of leased warps.

**5.** A warp rearrangement device as claimed in claim 4, wherein the plurality of tip holding portions can be moved along, and fixed at optional positions of, an imaginary arc centered on the warp-beam-side holding position of the intermediate holding portion.

**6.** A warp rearrangement device as claimed in claim 4, further comprising a separate thread separation mechanism for each warp sheet.

**7.** A warp rearrangement device as claimed in claim 4, further comprising a slave movement mechanism for moving the thread separation mechanism, the thread end transport mechanism, the leasing mechanism, and the thread end fixing mechanism to follow changes in position of sheet edges of the warp sheets associated with separation and transport of the warps of the warp sheets.

**8.** A warp rearrangement device as claimed in claim 4, wherein the thread separation mechanism pulls the separated warp towards a thread-end catching position of the thread end transport mechanism, the thread separation mechanism pulling a thread portion of the separated warp located between the warp-beam-side holding position of the intermediate holding portion and a thread-tip holding position of the corresponding tip holding portion, and further comprising a cutting portion that cuts the thread end of the warp after the warp is transported to the thread-end catching position and held thereat by the thread-end holding portion.

**9.** A warp rearrangement device as claimed in claim 4, further comprising:

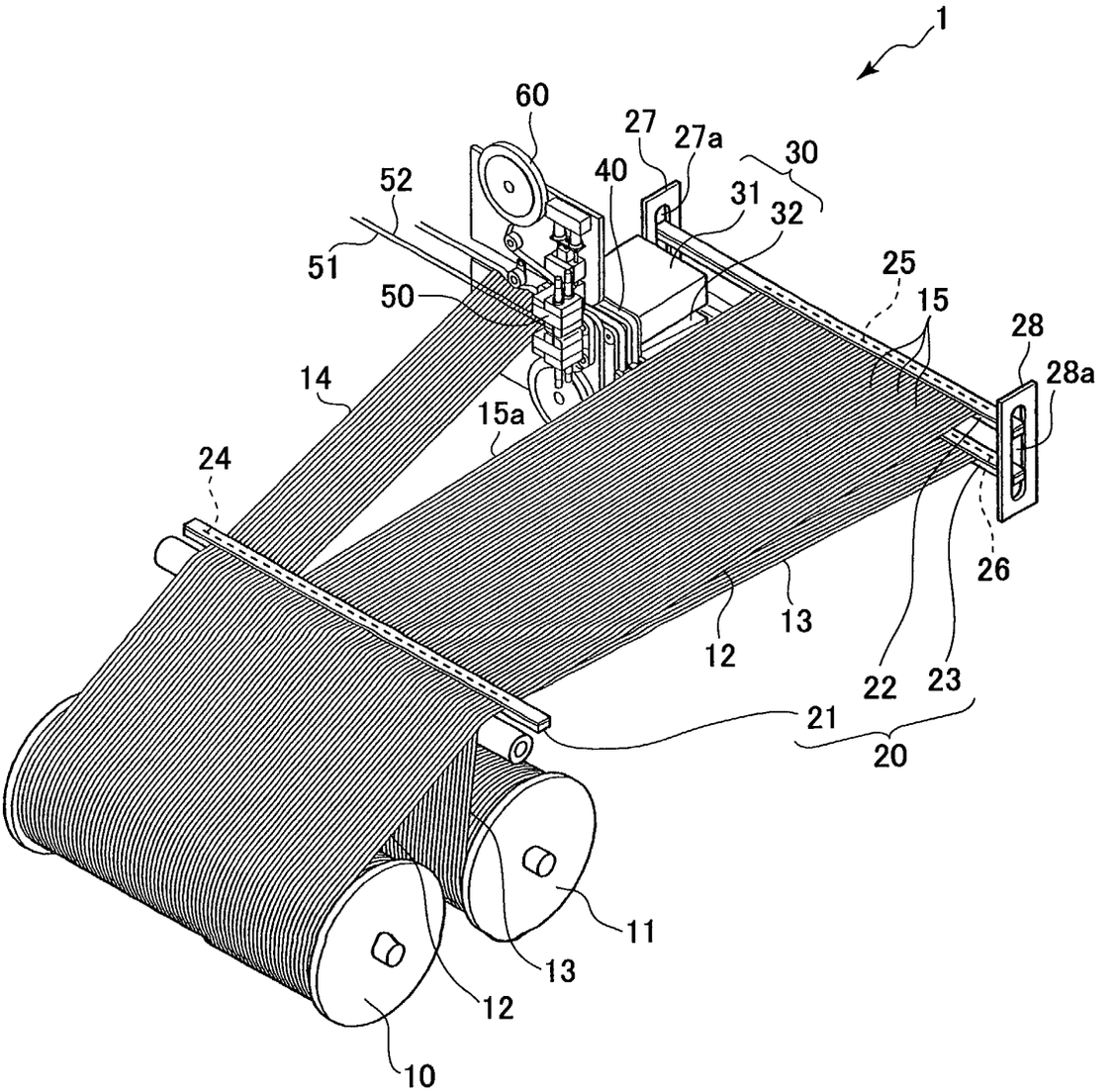
a plurality of thread separation mechanisms each for separating threads from a different warp sheet; and
a forward/reverse movement mechanism for moving the thread separation mechanisms independently between the thread-end holding portion and a sheet edge of the corresponding warp sheet.

**10.** A warp rearrangement device as claimed in claim

9, further comprising a cutting portion that simultaneously cuts the warp separated by one of the thread separation mechanisms at portion of the warp located between the warp-beam side holding position and the thread-tip holding position and holds the cut warp, and that releases the thread end of the warp after the forward/reverse movement mechanism pulls the warp to the thread-end catching position and the transport holding portion holds the thread.

**11.** A warp rearrangement device as claimed in claim 4, wherein the thread end fixing mechanism uses a pair of adhesive tapes to fix the thread end of the leased warps.

FIG.1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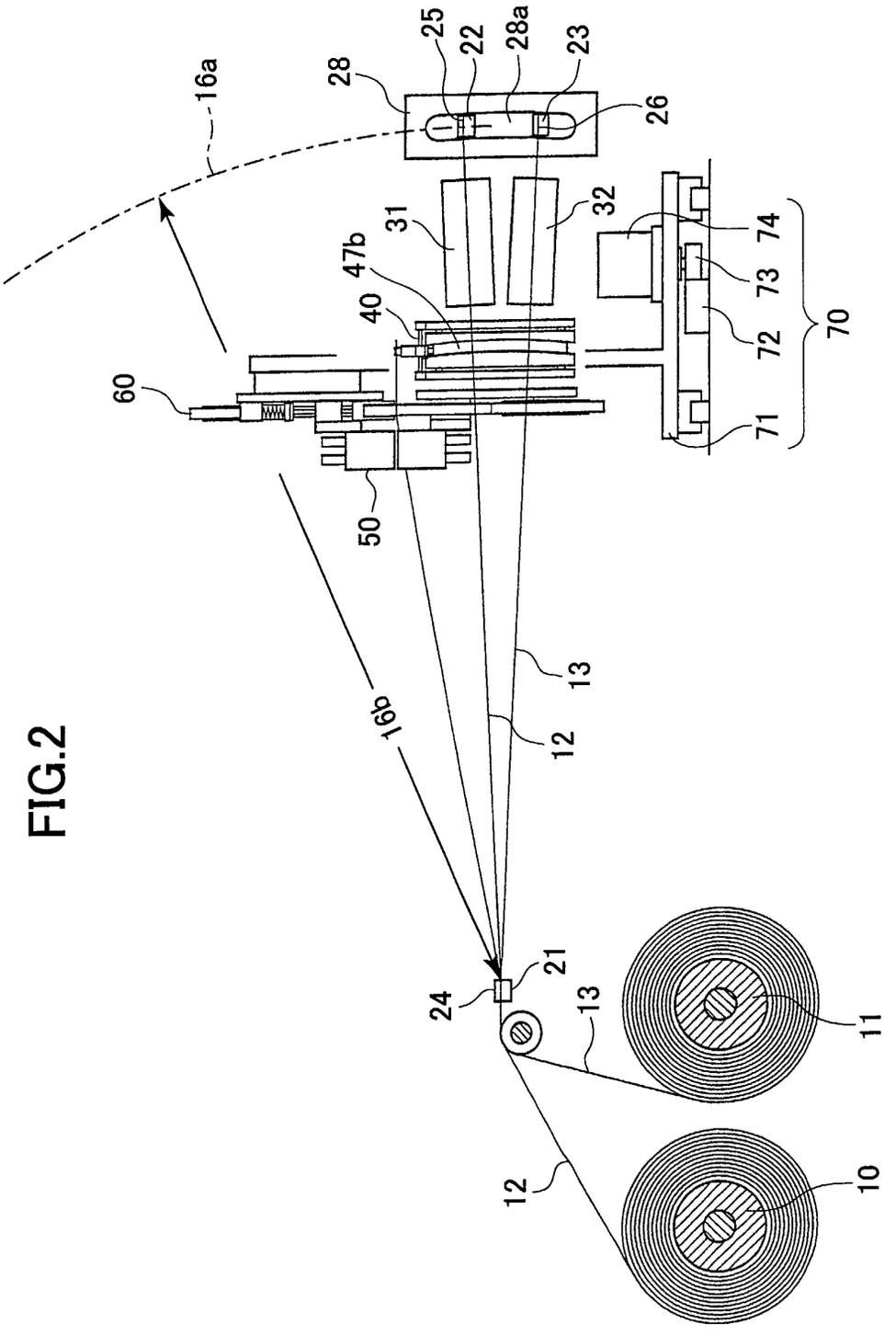
23
21
20
11
13
12
10

FIG.2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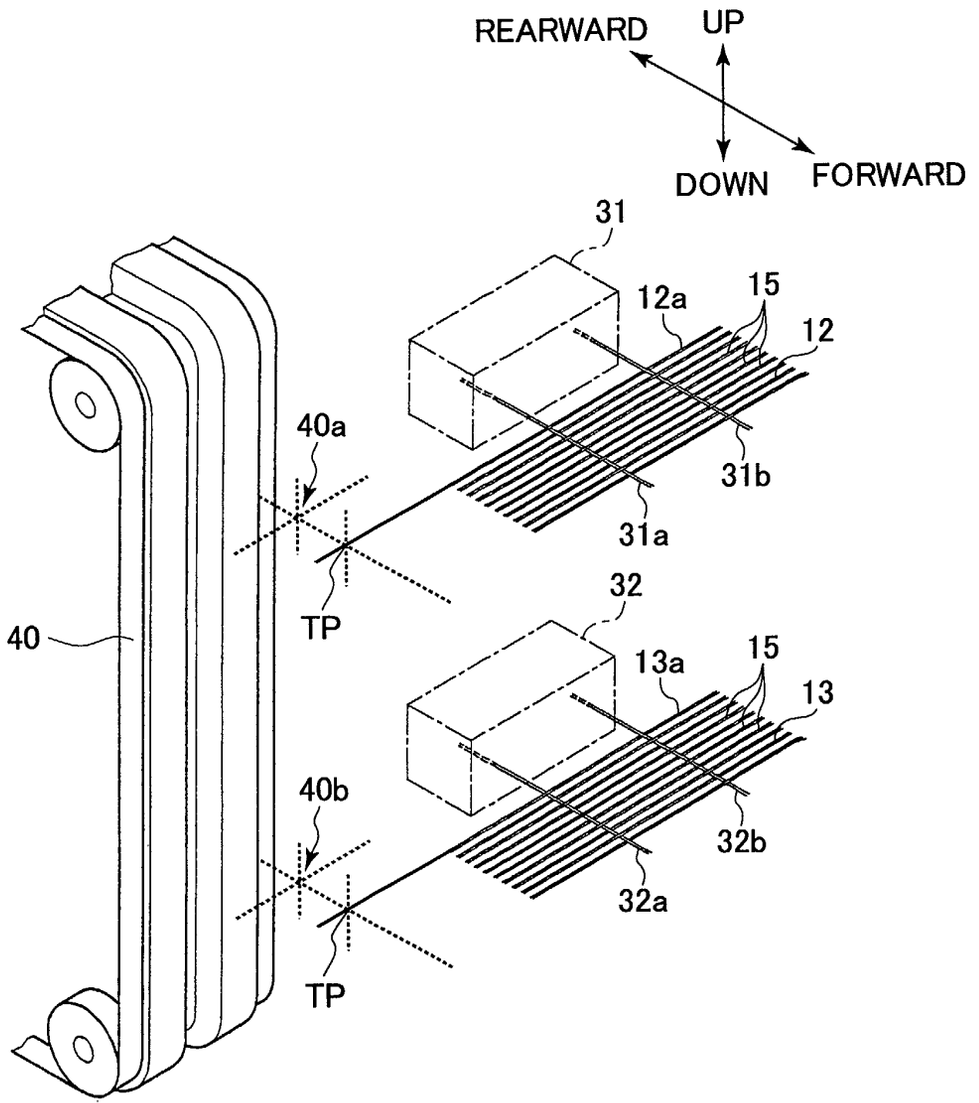
21
13
11
12
10

FIG.3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13a
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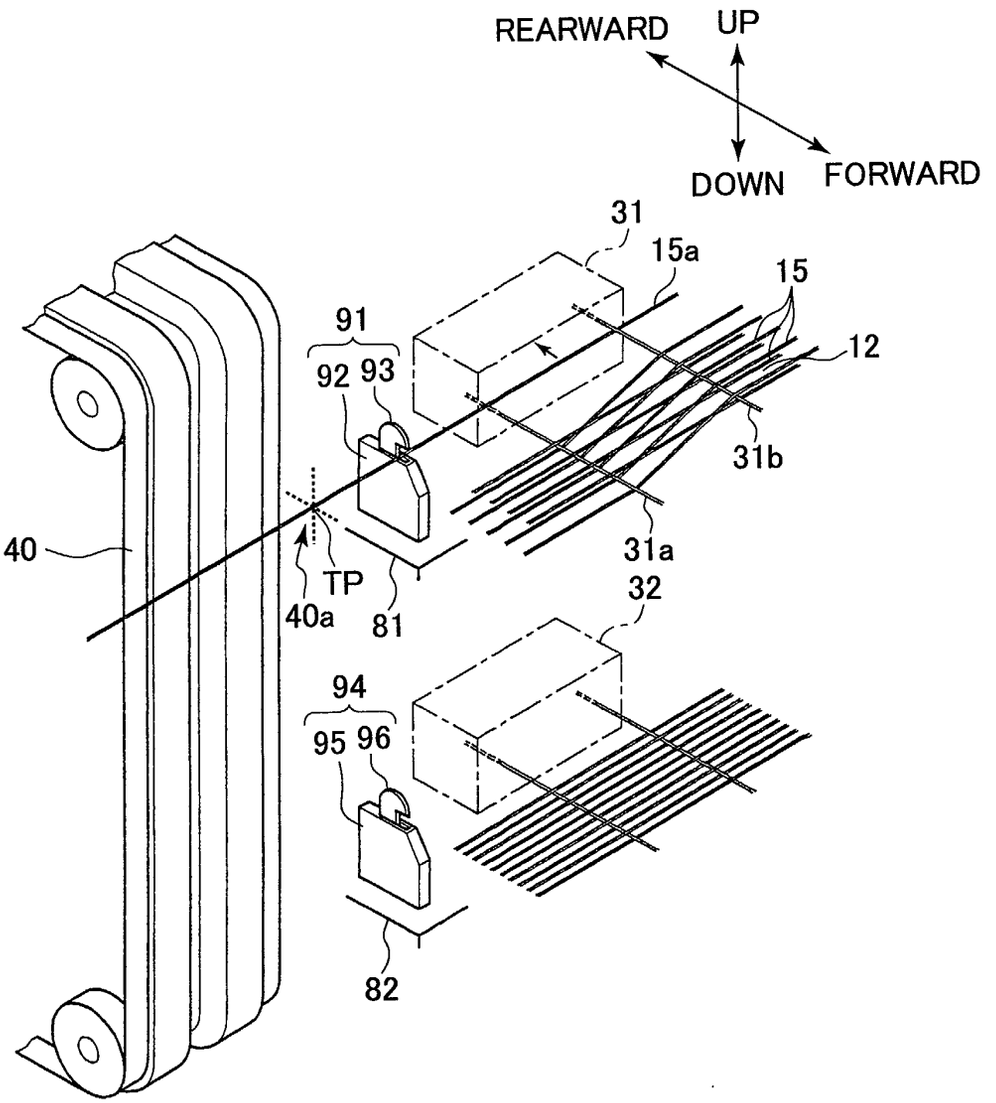
TP
40b
32b
32a
TP

FIG.4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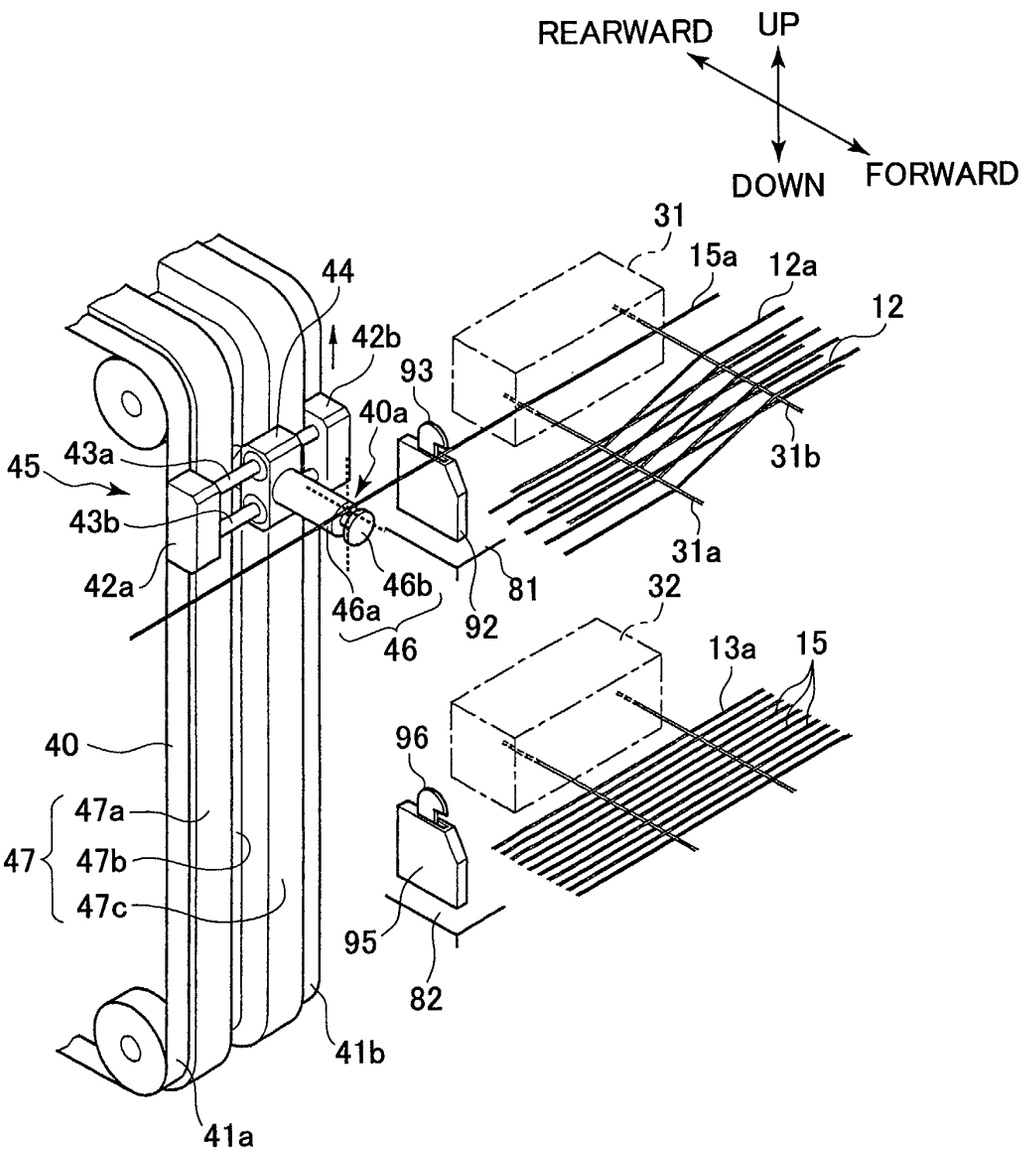
31a
32
94
95
96
82

FIG.5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43b
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46a
46
92
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40
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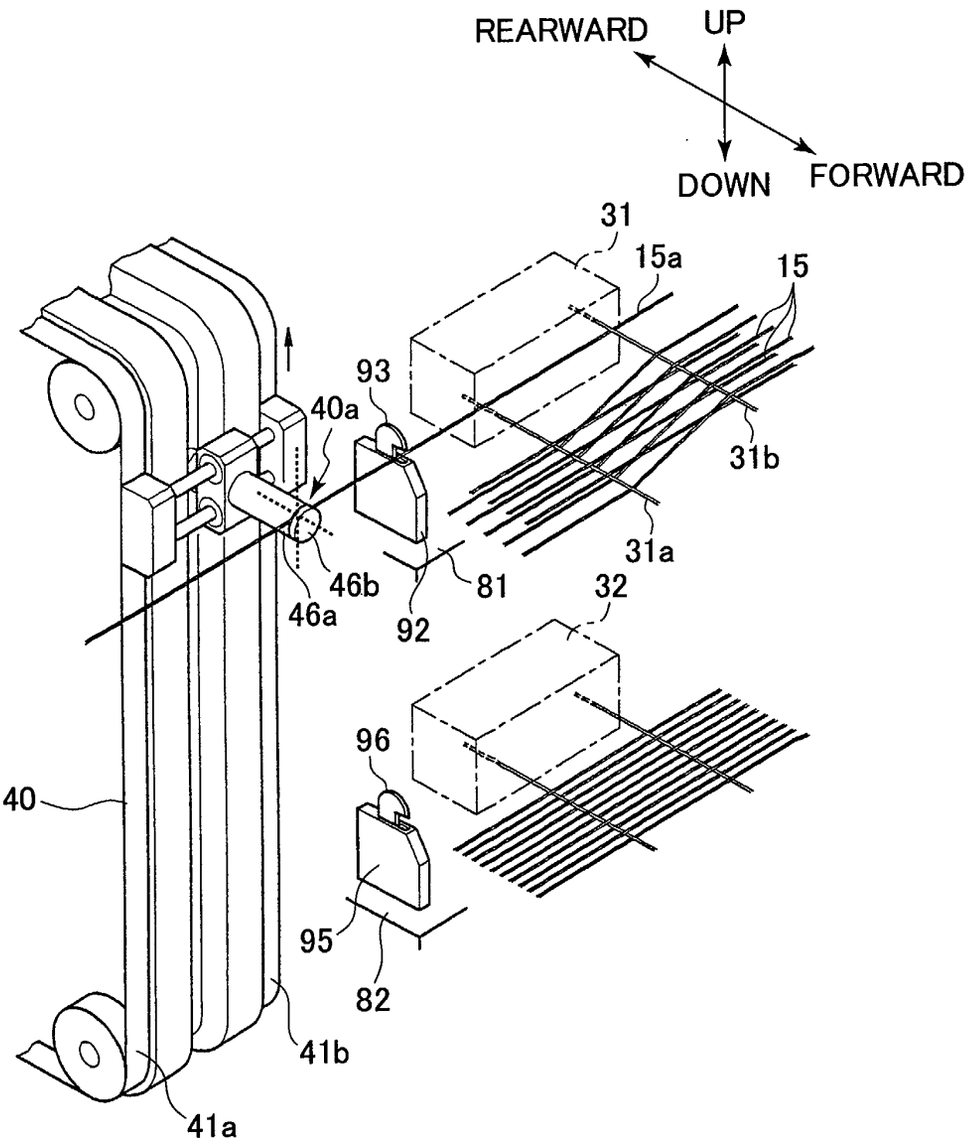
47a
47b
47c
95
82
41b
41a

FIG.6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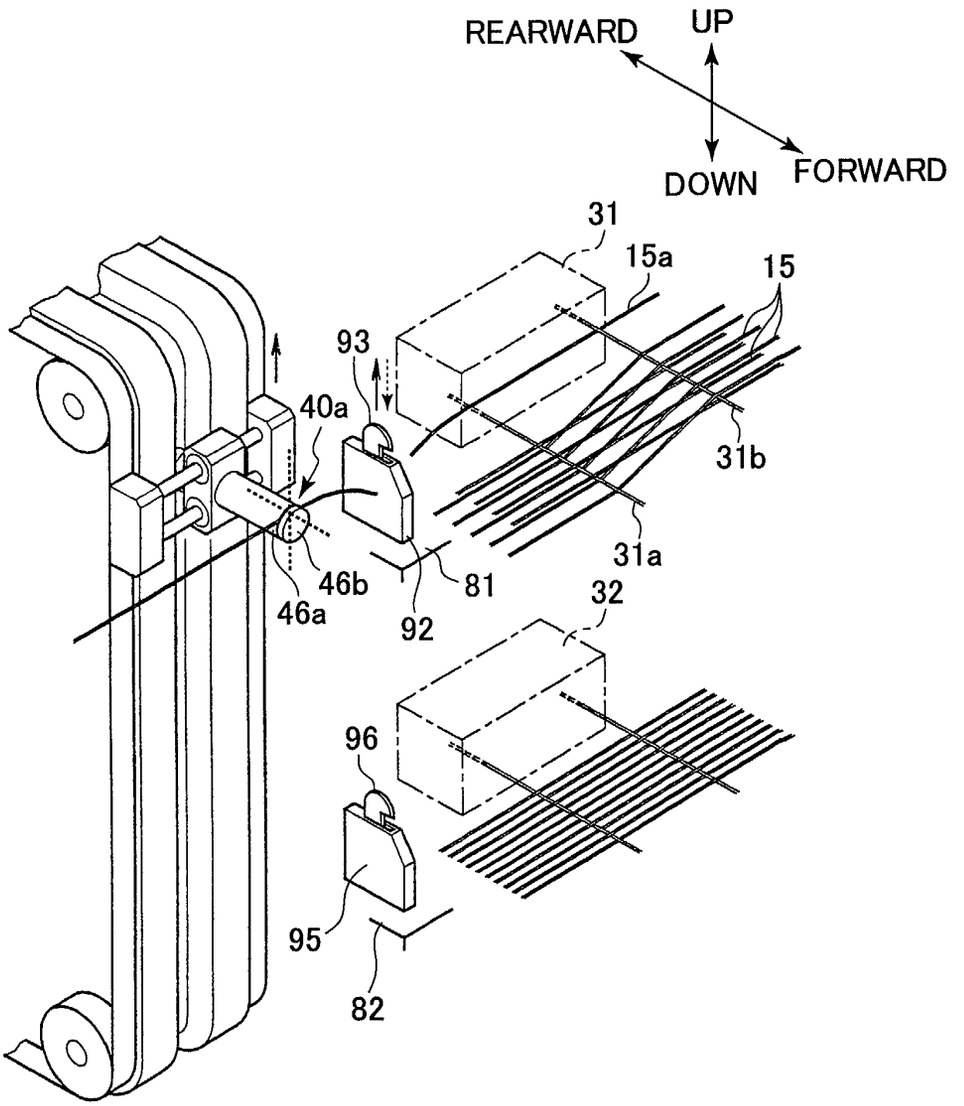
40
95
82
41b
41a

FIG.7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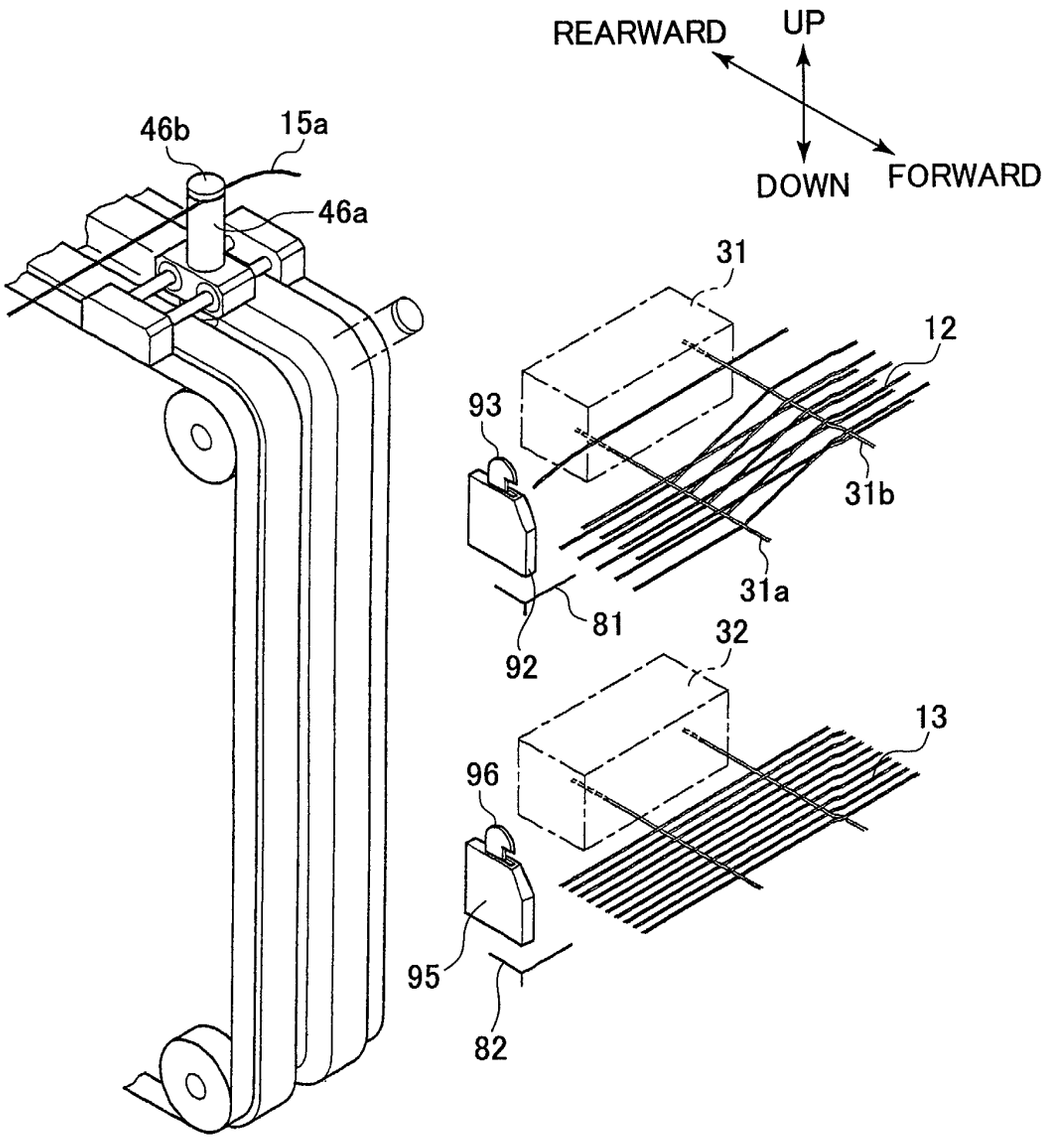
82

FIG.8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31b
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13
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95
82

FIG.9

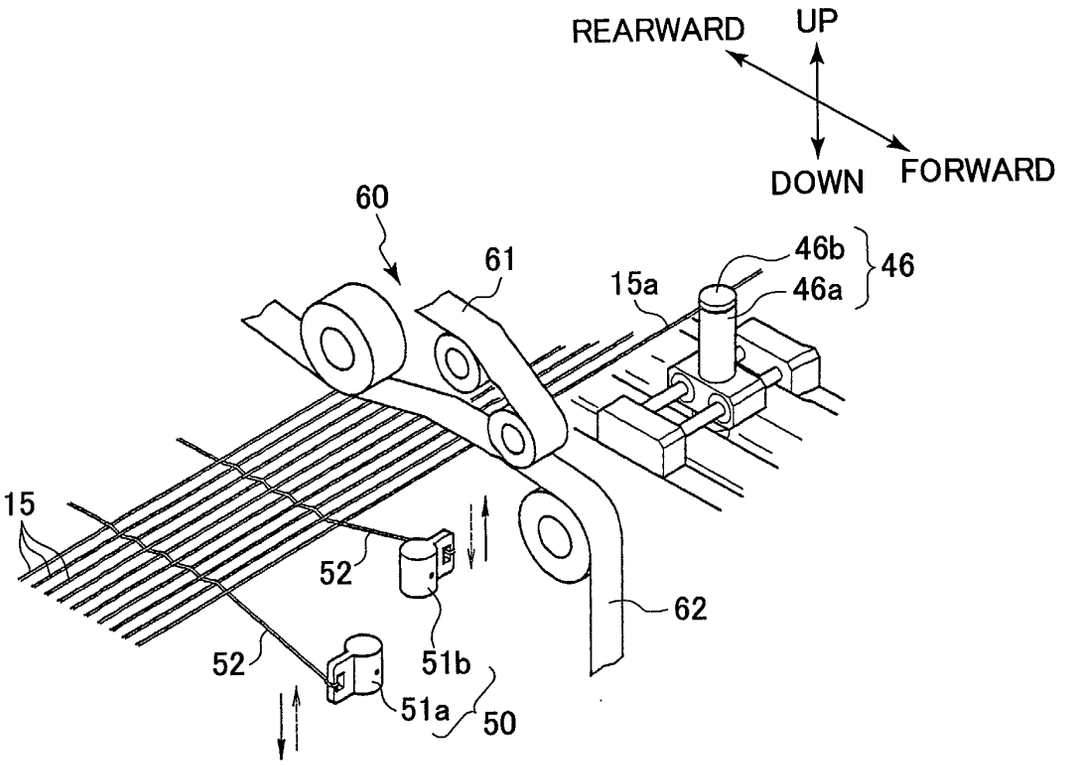
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FIG.10

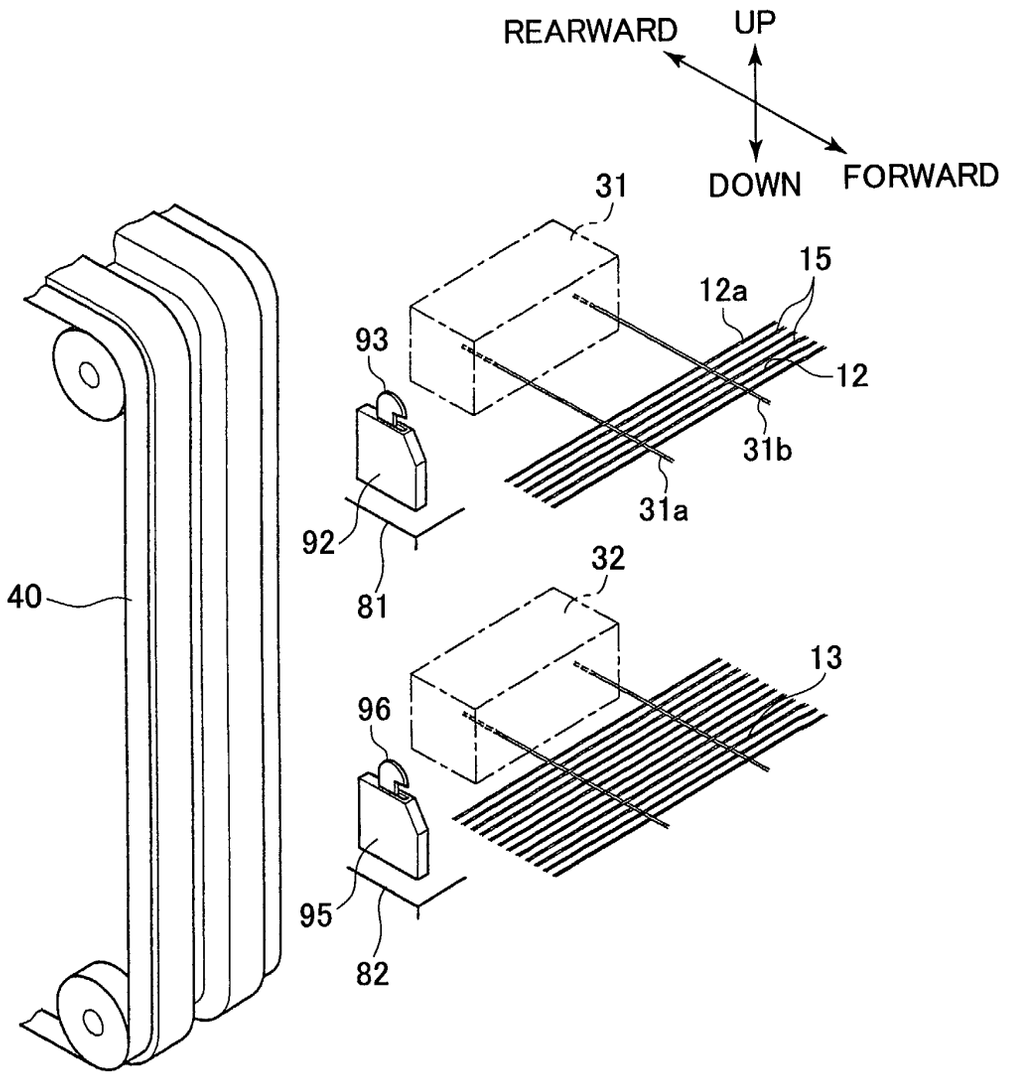
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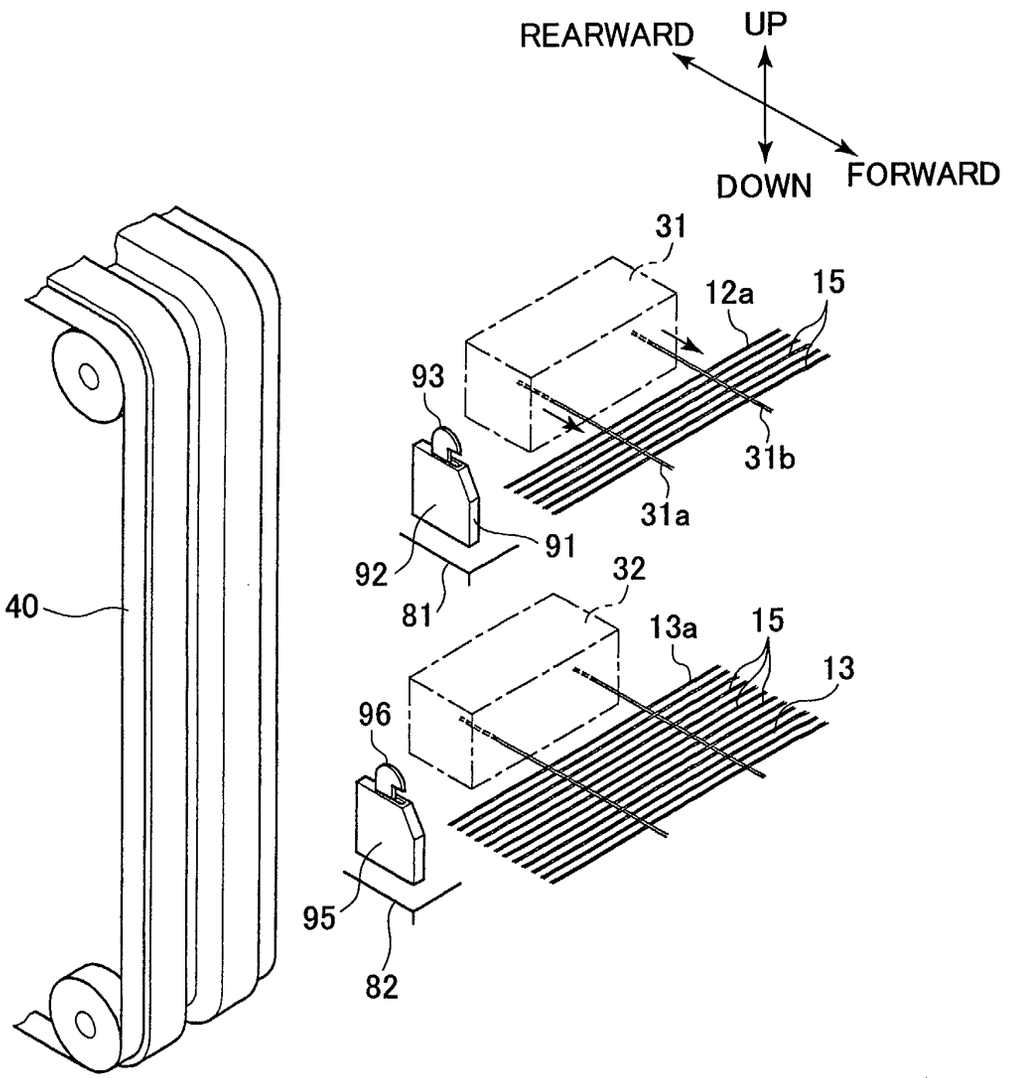
FIG.11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96
95
82
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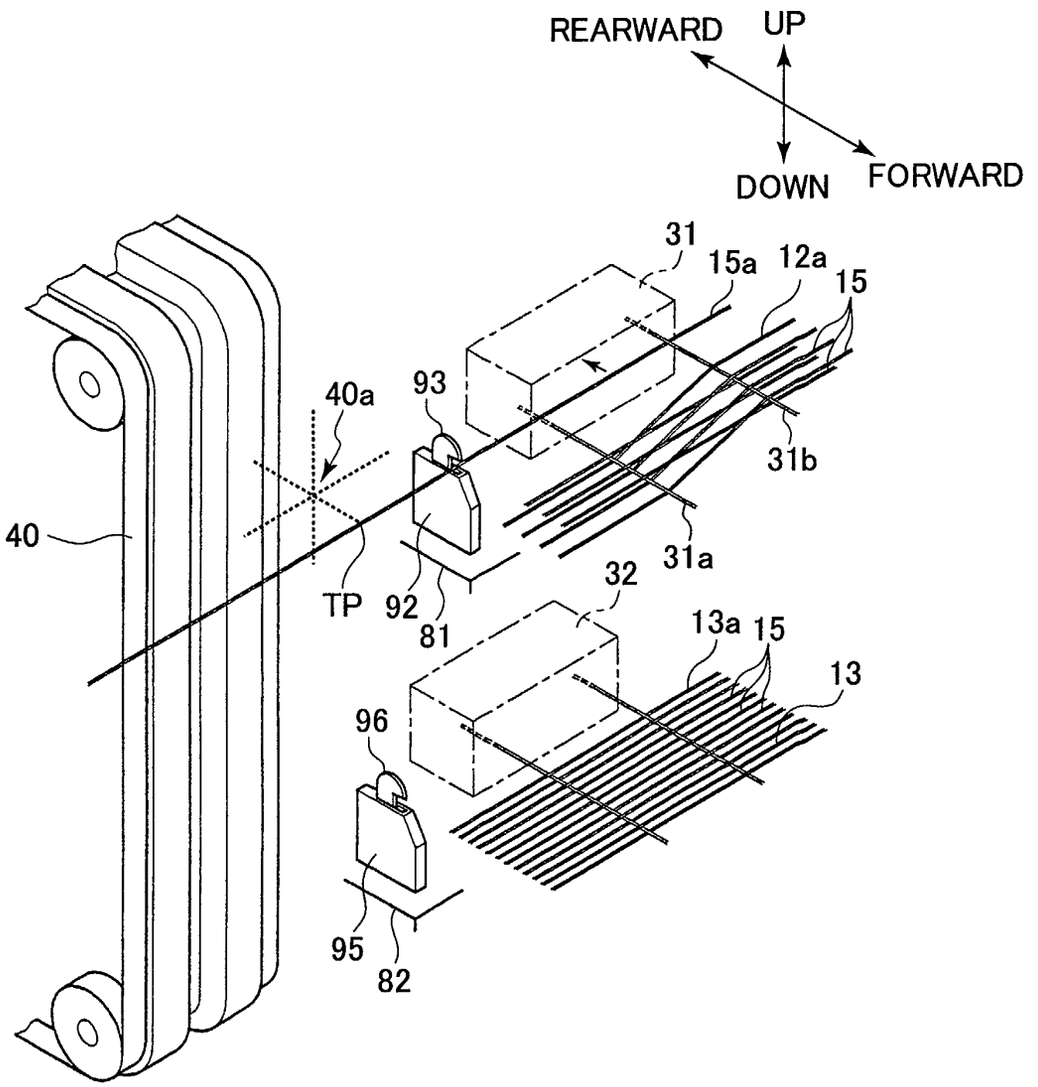
FIG.12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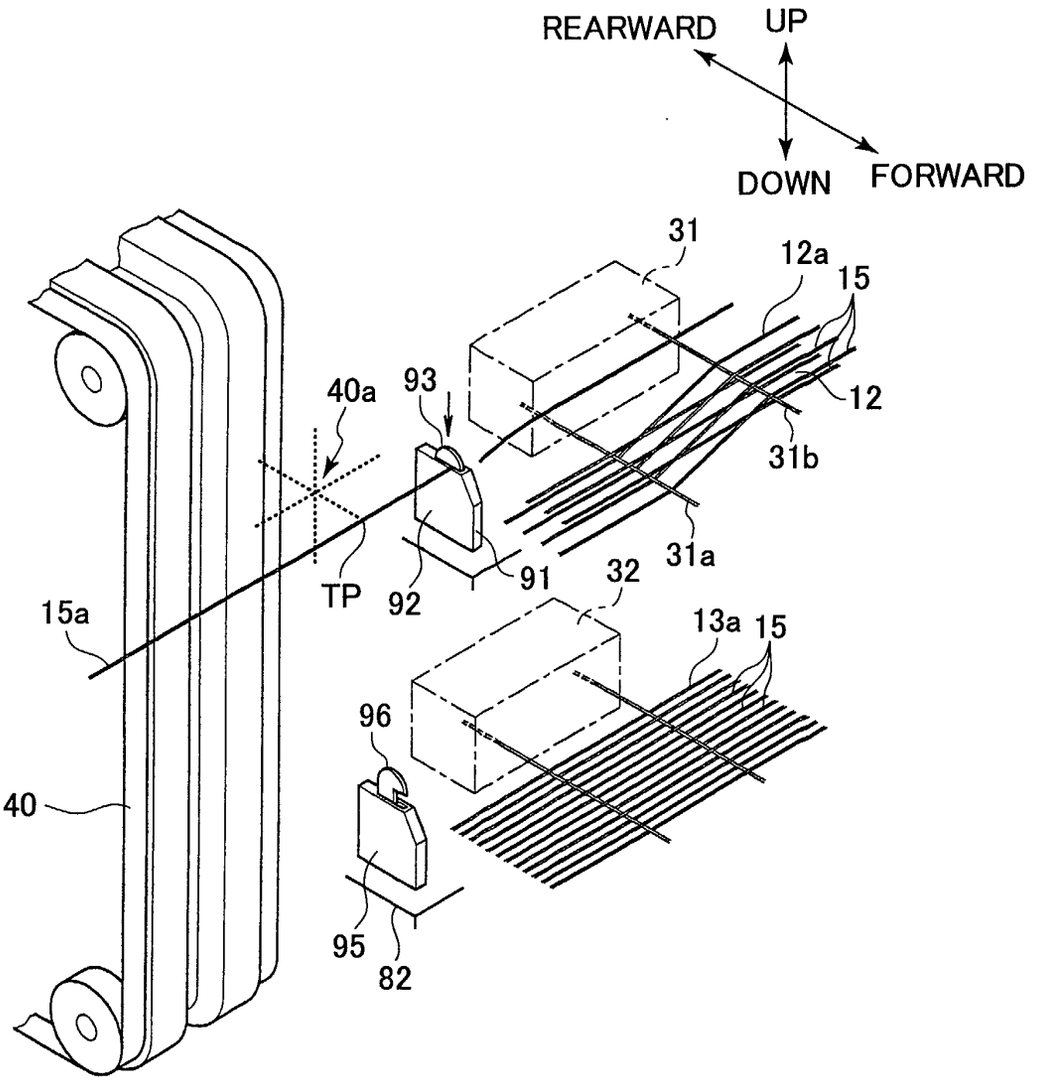
95
82

FIG.13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31a
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15a
13a
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FIG.14

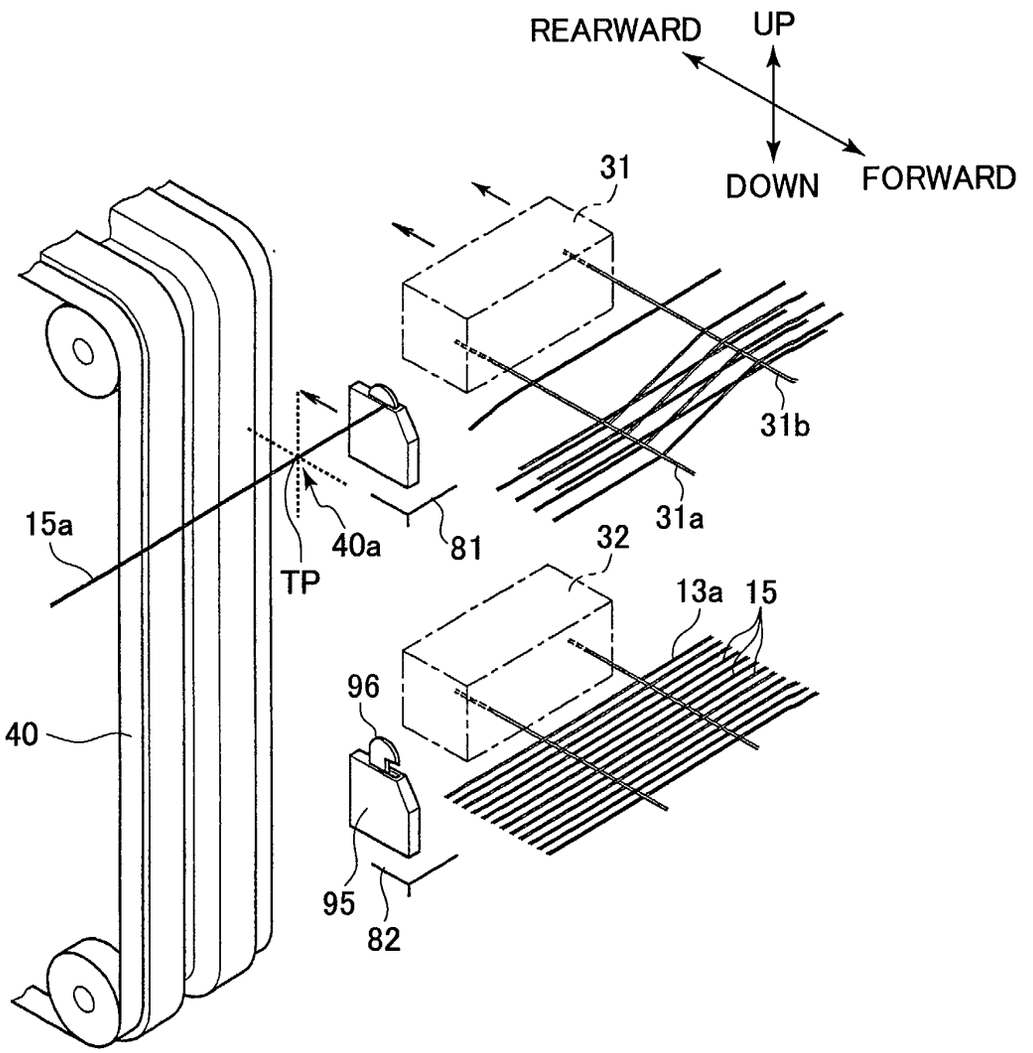
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FIG.15

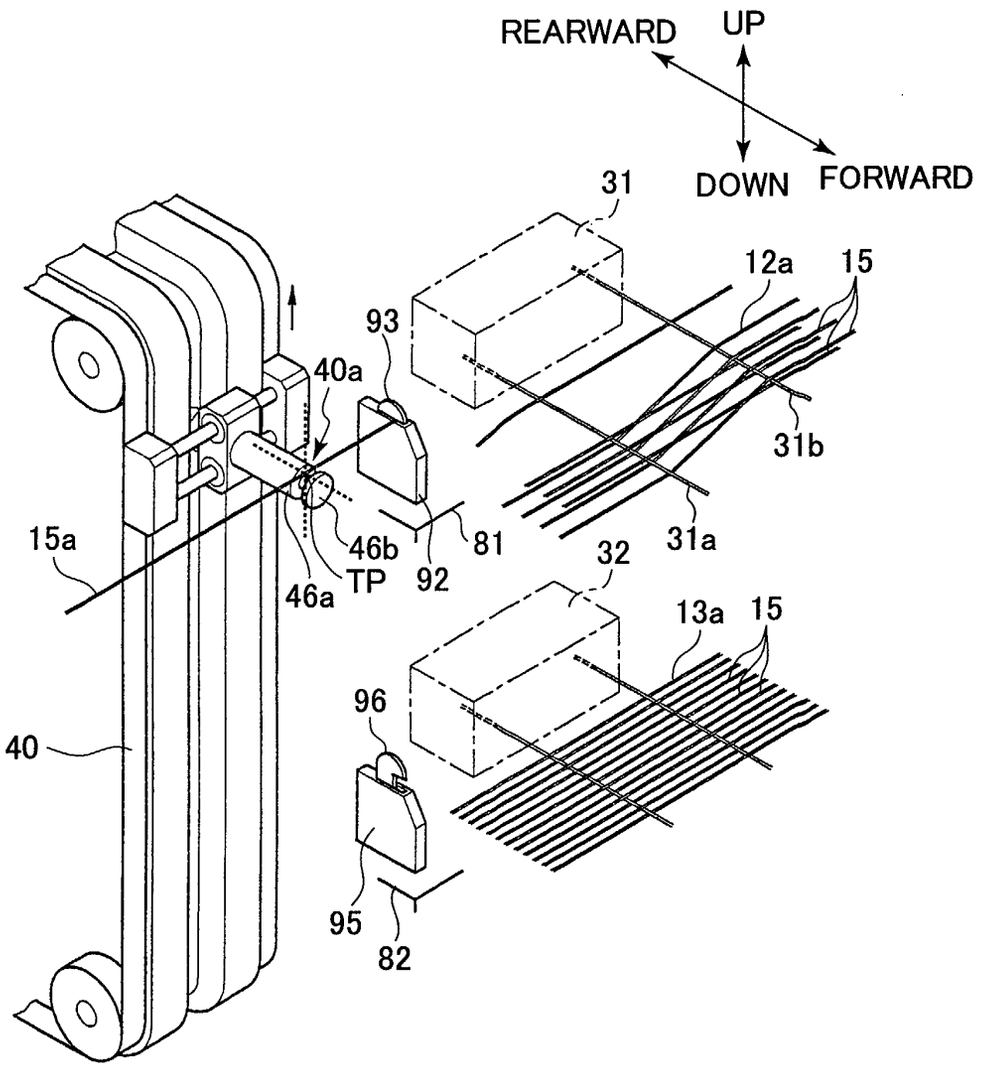
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FIG.16

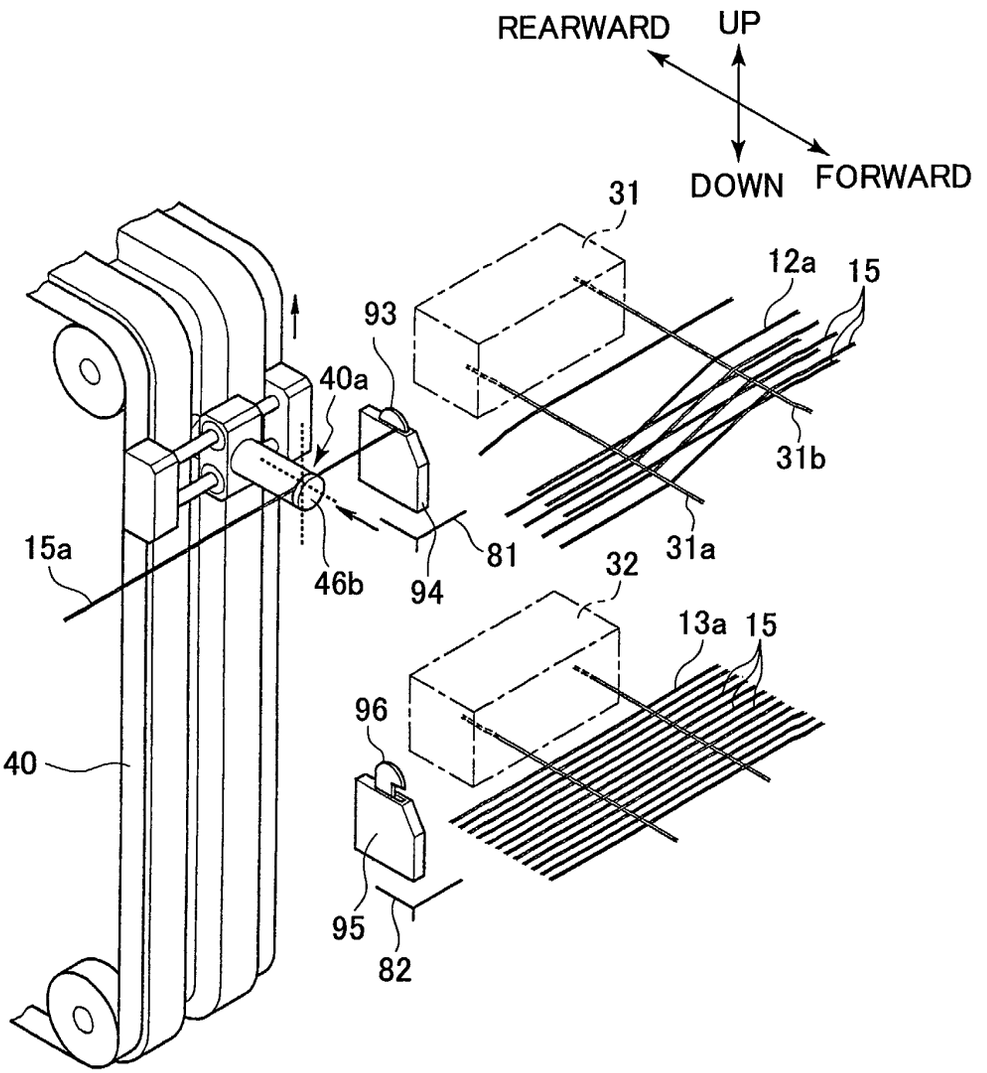
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FIG.17

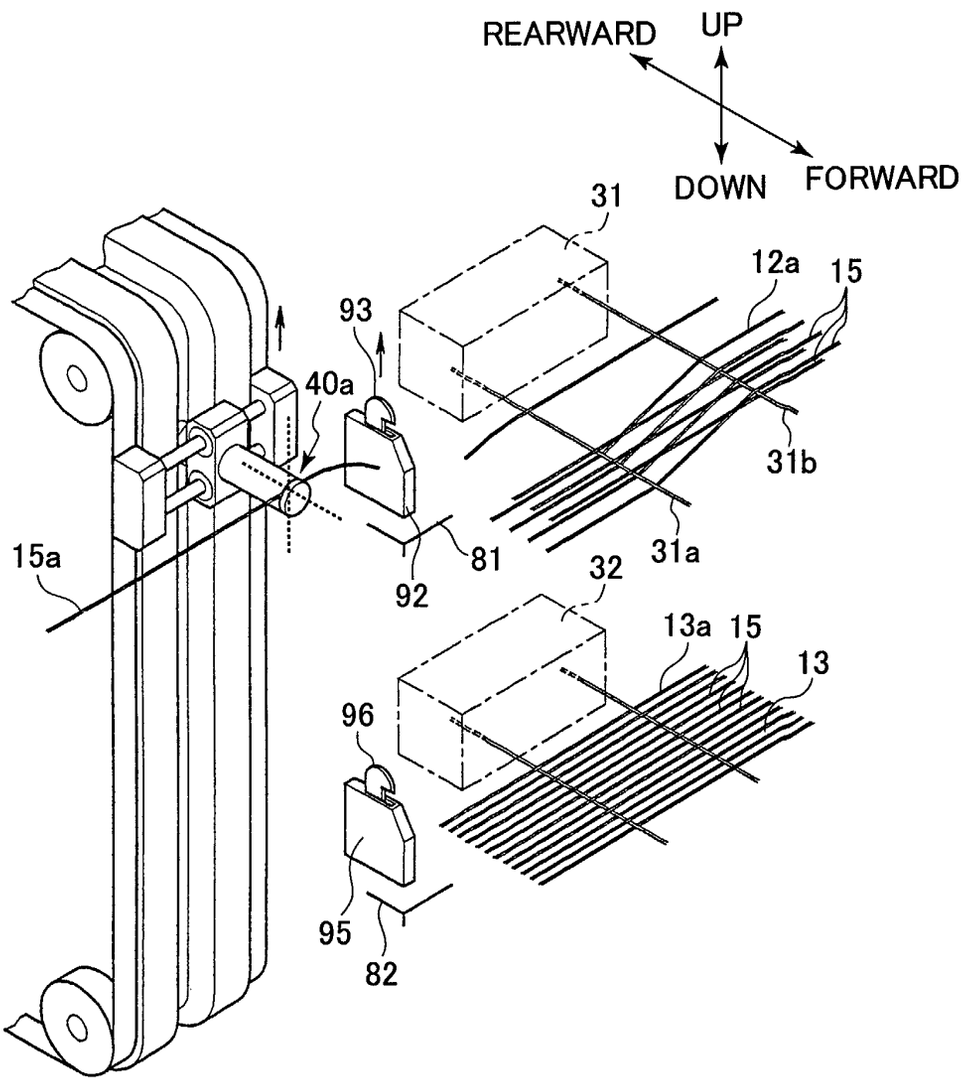
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FIG.18

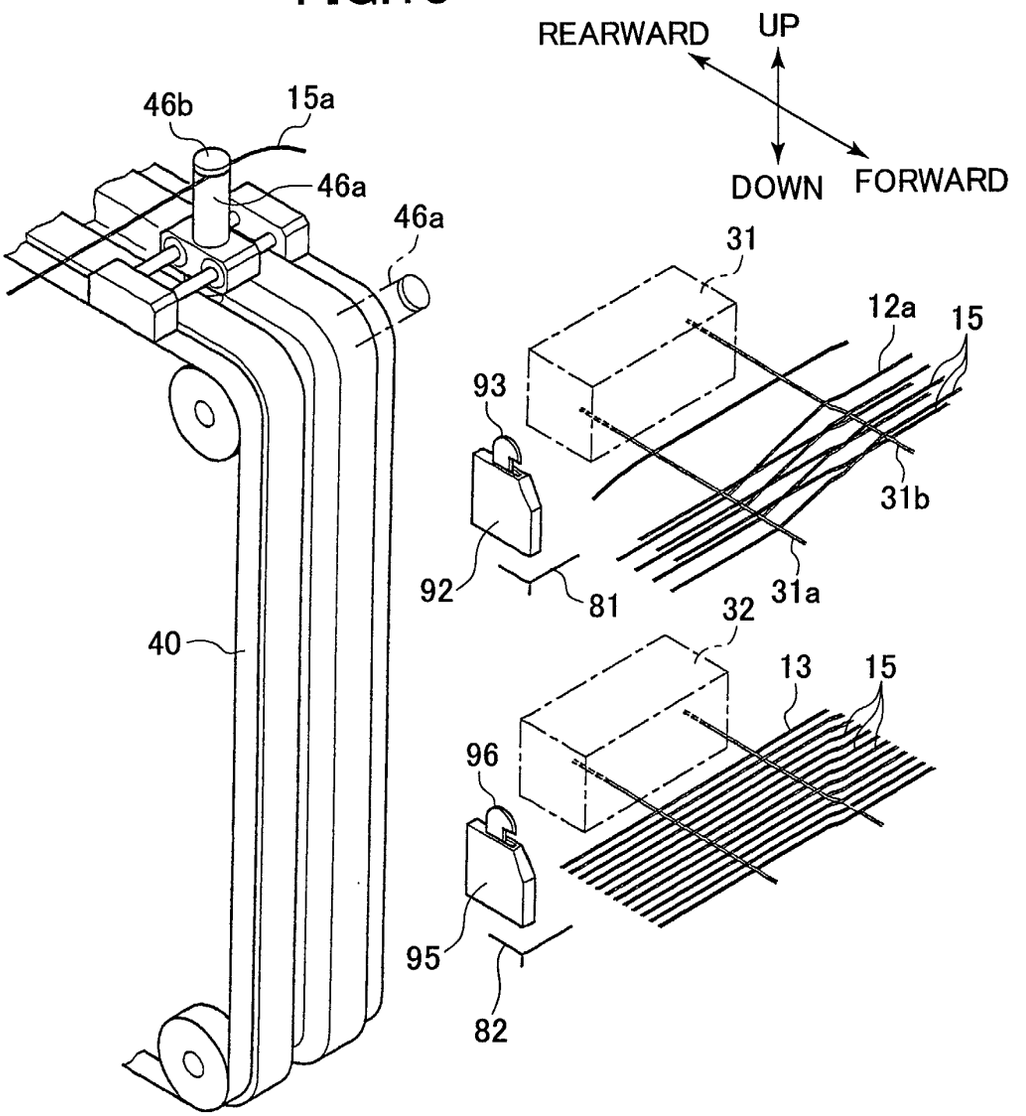
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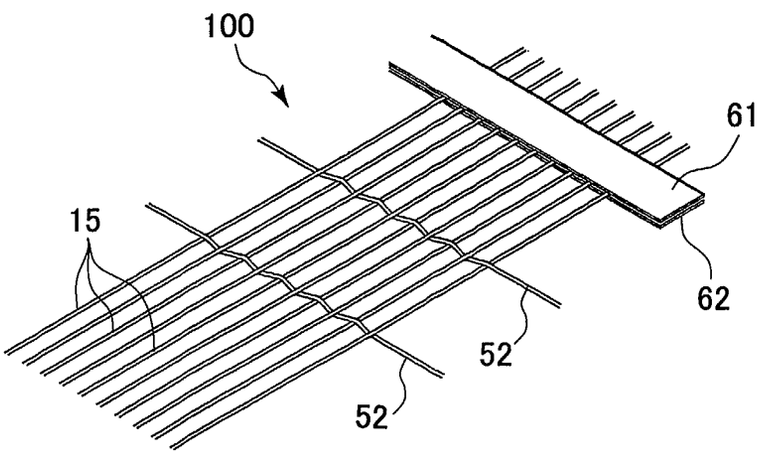
FIG.19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